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Impact protection assessment of the redesigned Oregon Aero ZetaLiner fitting system in the HGU-56/P Aircrew Integrated Helmet System

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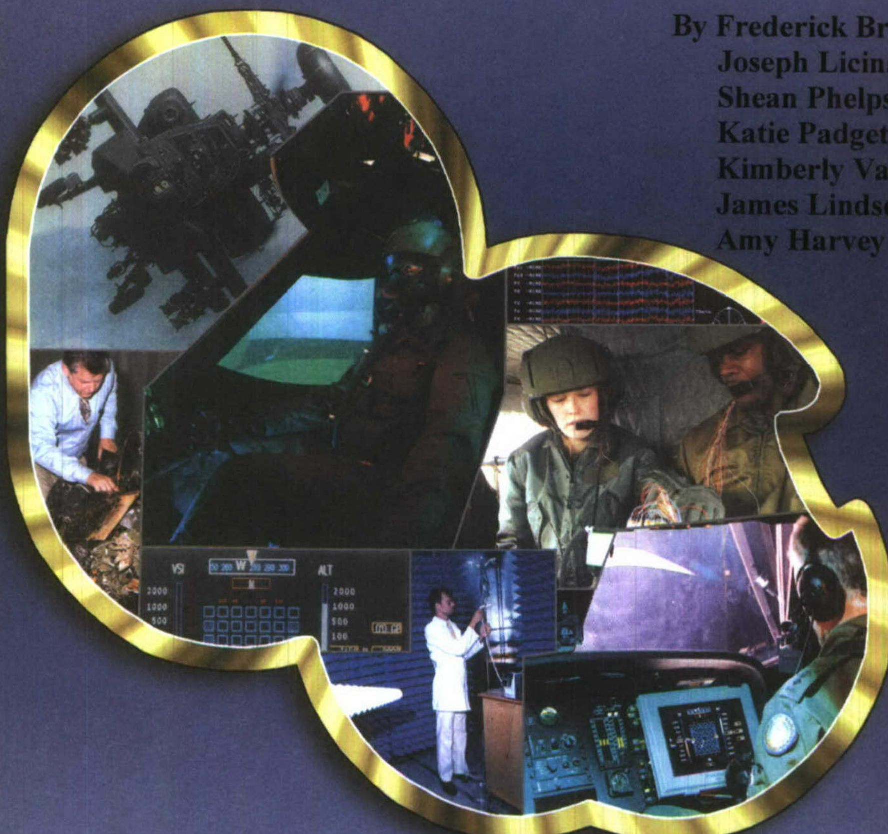

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14. ABSTRACT

The HGU-56/P Aircrew Integrated Helmet System (AIHS) uses the thermoplastic liner (TPL®) to provide wearers with a custom helmet fit. While the TPL® provides a comfortable helmet fit for most HGU-56/P AIHS wearers, there is a portion of the aviation warfighter population who cannot be comfortably accommodated by the TPL®. Oregon Aero, Inc. markets an alternative helmet fitting system for the HGU-56/P AIHS (this fitting system is referred to as the ZetaII throughout the manuscript). The impact of replacing the TPL® with the ZetaII fitting system on the blunt impact protection provided by the HGU-56/P AIHS is unknown. Fifty two (52) new HGU-56/P AIHSs in four sizes (small, medium, large, and extra-large) were subjected by blunt impact evaluations in accordance with the HGU-56/P purchase description. The TPL® in each helmet was replaced with a ¼-inch thick ZetaII fitting system. Peak head accelerations measured during these trials were compared to peak head acceleration limits (continued)

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Listed in the HGU-56/P AIHS purchase description; peak head accelerations exceeding the limits set forth in the purchase description represented reduced blunt impact protection. Peak head accelerations measured during this evaluation remained below these specified limits, indicating that the impact protection of the HGU-56/P AIHS is not degraded with the use of the ZetaII fitting system.

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Introduction

Over the past 30 years, U.S. Army aviation helmet fitting systems have been continually refined in attempts to enhance helmet stability, retention, and wearer comfort. Early hard-shell helmets, like the APH-5, used leather-covered foam pads of varying thicknesses to achieve a custom fit. In 1969, the SPH-4 helmet was introduced into service and incorporated an adjustable sling suspension system (Figure 1). The inner basket of the Integrated Helmet and Display Sighting System (IHADSS), which is unique to the AH-64 Apache helicopter, uses front and rear pads in combination with a vertically adjustable inner basket assembly (Figure 2); brow and nape pads are used to customize the fore-aft position of the helmet.

Figure 1. Sling suspension helmet fitting system.

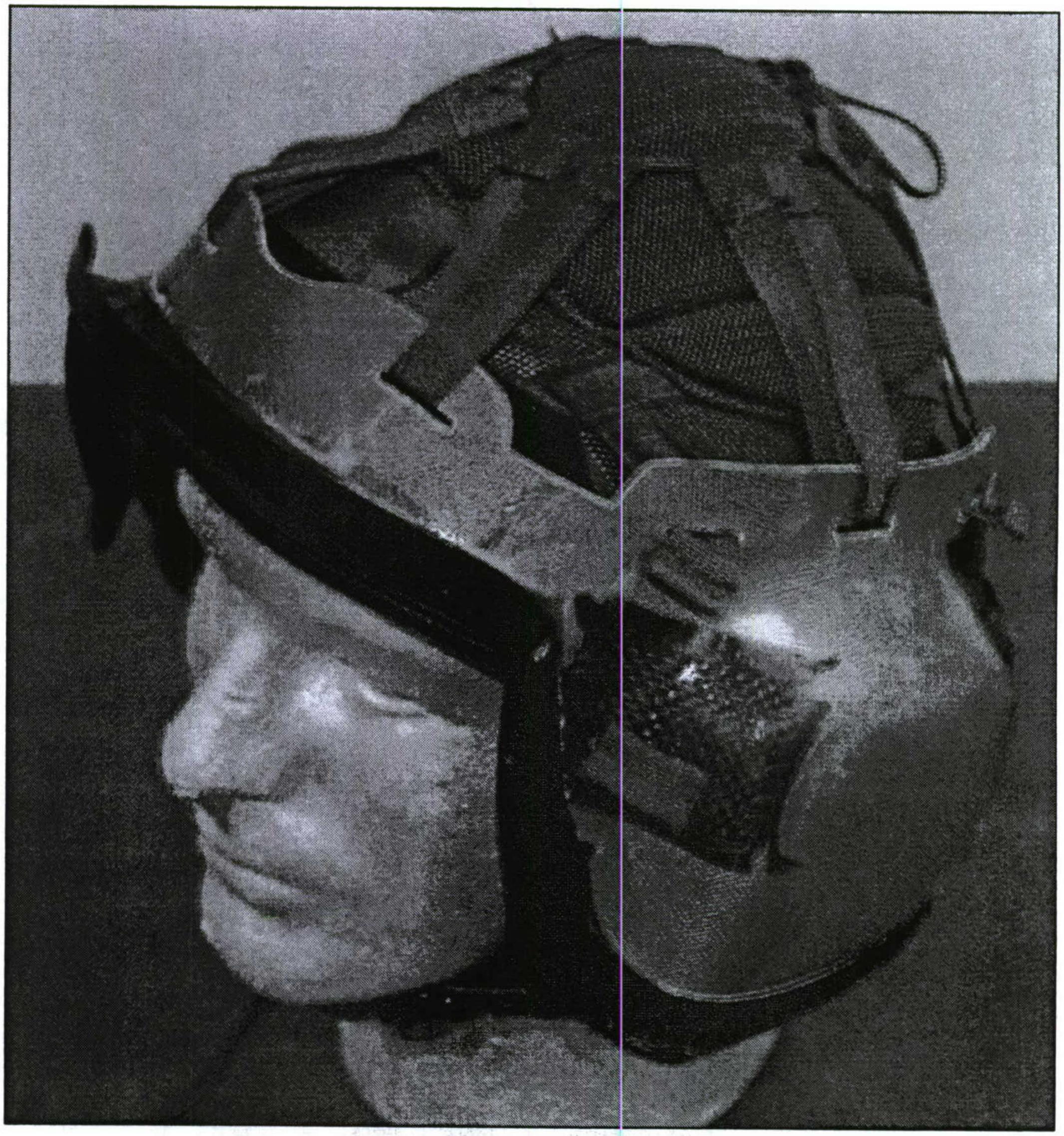

Figure 2. IHADSS basket fitting system. Not shown are the brow and nape pads.

The successor to the SPH-4, the SPH-4B, as well as the Army's current primary rotary-wing aviation helmet, the HGU-56/P Aircrew Integrated Helmet System (AIHS) (Gentex Corporation, Carbondale, PA), uses the thermoplastic liner (TPL®) to provide individual aircrew members with a customized fit (Figure 3). The TPL® is comprised of four layers of thermoplastic sheets (each formed with egg carton-type dimples) covered with a washable cloth cover. Individual fitting is accomplished by heating the TPL® until the thermoplastic layers become pliable, then having the individual don the TPL® and helmet until the thermoplastic sheets have cooled and formed to the shape of the wearer's head (McEntire, 1998).

Figure 3. Gentex Corporation TPL® fitting system.

The TPL® provides most aircrew with a custom, comfortable, and stable helmet fit. However, the TPL® does not accommodate the entire U.S. Army aircrew member population, particularly those individuals with atypical head anthropometry. A limited number of current users have anecdotally cited the TPL® as causing hot spots. Hot spots are defined as areas on the wearer's head where helmet weight produces high pressure, thus causing discomfort.

Oregon Aero, Inc. (Scappoose, OR) markets an alternative helmet fitting system, the ZetaLiner™, for use in several models of aviation helmets, including the HGU-56/P AIHS. The ZetaLiner™ (Figure 4), which is comprised of sections of visco-elastic foam sewn into a washable cloth outer covering, is purported to reduce the occurrence of hot spots. The visco-elastic foam compresses under the weight of the helmet and conforms to the contours of wearer's head, providing a custom fit. To increase comfort during rotary-wing operations, U.S. Army

aviation warfighters have procured ZetaLiners™ and installed them in HGU-56/P flight helmets, even though the product has not been approved for use.

Figure 4. Oregon Aero original ZetaLiner™ fitting system.

The Product Manager, Air Warrior (PM-AW), who oversees the fielding and configuration of all U.S. Army aviation life support equipment (ALSE), including the HGU-56/P AIHS, recognized that Army aviation warfighters were procuring these devices and installing them in their HGU-56/P flight helmets despite their unapproved status. To determine whether use of the ZetaLiner fitting system would degrade the impact protection provided by the HGU-56/P flight helmet, the PM-AW funded the U.S. Army Aeromedical Research Laboratory (USAARL), Fort Rucker, AL, to perform qualification testing of the ZetaLiner fitting system. These qualification tests were conducted at the USAARL in August 2004.

These qualification tests showed that use of the ZetaLiner™ in the HGU-56/P AIHS degraded the impact protection of the helmet, particularly during impacts to the rear aspect of the

helmet. The diminished performance was further exacerbated by high temperature environments. Based on these results, the PM-AW promulgated ALSE Message 05-01, reiterating that ZetaLiner™ fitting systems were never approved for use with the HGU-56/P AIHS and instructing aviators to remove ZetaLiners™ from their HGU-56/P flight helmets.

Oregon Aero, Inc., has designed an HGU-56/P-specific ZetaLiner™-type fitting system (herein referred to as the ZetaII) (Figure 5) to address the blunt impact performance degradation noted in previous testing. The objective of this study was to determine the influence of the ZetaII fitting system on the blunt impact protection characteristics of the HGU-56/P AIHS.

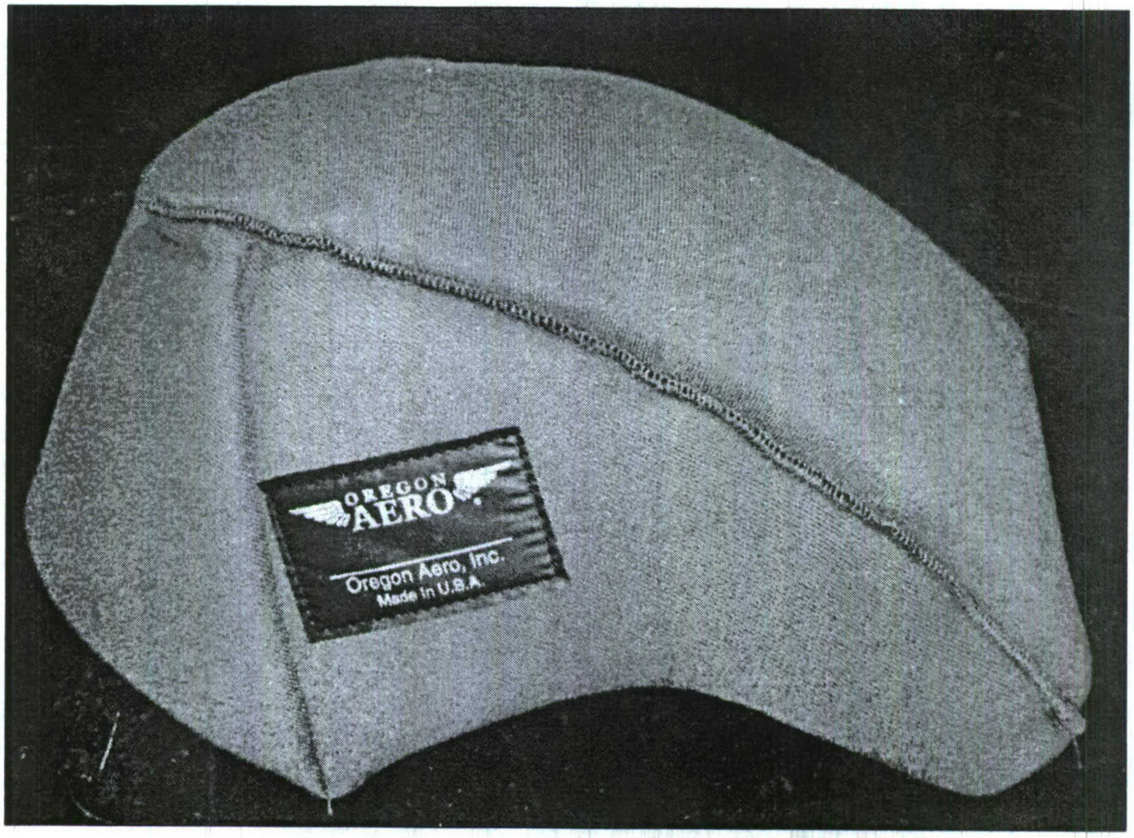

Figure 5. Oregon Aero HGU-56/P-specific ZetaII fitting system. ZetaII fitting systems lack the exposed seam that runs down the top, centerline of the original ZetaLiner™ fitting system as shown in Figure 4. Oregon Aero, Inc. has assigned unique part numbers to the various lengths and sizes of ZetaII fitting systems (Appendix B).

Materials and methods

Experimental equipment

Helmets

The HGU-56/P flight helmet (Figure 6) is available in sizes: extra-extra-small (XXS), extra-small (XS), small(S), medium (M), large (L), and extra-large (XL). Each helmet is made up of a laminated composite (carbon fiber and Spectra) shell, expanded bead polystyrene energy absorbing liner, energy attenuating earcups with foam filled earpads, integrated chin- and nape-straps, communications system, and dual visor assembly (clear and smoked visors).

Figure 6. U.S. Army HGU-56/P AIHS.

Fifty-two new HGU-56/P flight helmets were used during this investigation. The number of helmets tested per size is shown in Table 1. The XS and XXS HGU-56/P helmet sizes were not evaluated. These two sizes of helmet share the same helmet shell as the small HGU-56/P, but accommodate smaller head anthropometries than the small HGU-56/P. This is accomplished by

thickening the polystyrene energy-absorbing liners (EALs) in the XS and XXS helmets. Due to the thicker EALs, XS and XXS HGU-56/P helmets provide inherently better blunt impact protection than the small HGU-56/P. The small HGU-56/P was included in this evaluation with the expectation that if small HGU-56/Ps equipped with the ZetaII fitting system provided adequate blunt impact protection, XS and XXS HGU-56/Ps equipped with the ZetaII fitting system should also provide adequate blunt impact protection due to their relatively thicker EALs.

Table 1.
HGU-56/P helmet test assets by helmet size and helmet version.

Helmet size	Number of helmets		
	Standard	Lightweight	Total
Extra-extra-small	0	0	0
Extra-small	0	0	0
Small	12	2	14
Medium	8	6	14
Large	7	5	12
Extra-large	7	5	12

The 52 helmets were a combination of standard-issue and lightweight versions of the HGU-56/P AIHS. Lightweight and standard-issue HGU-56/P flight helmets differ in four ways. In the lightweight version of the helmet,

- the blown air plenum port has been removed from the right rear of the helmet,
- the internal blown air plenum has been removed from the helmet shell,
- the foam nape pad and its leather cover have been replaced with synthetic materials, and
- the boom microphone swivel assembly has been replaced with a lighter weight version used on the IHADSS helmet.

These modifications are not expected to affect the blunt impact protection provided by the lightweight version of the HGU-56/P AIHS. Additionally, the helmet shell and energy-absorbing liner construction are the same between the two versions. As such, both versions of the HGU-56/P flight helmet provide equivalent blunt impact protection. For these reasons, both were considered suitable for this evaluation.

Helmet fitting systems

The 52 ZetaII fitting systems were installed in place of the four-layer TPL®, which is standard issue with the HGU-56/P AIHS. The length of the ZetaIIs used for this evaluation varied by helmet size (Table 2). ZetaII lengths were chosen such that when installed the ZetaII was level with the lower edge of the EAL at the front of the helmet, fit smoothly along the interior contour of the polystyrene liner, and mated completely with the hook and pile tape sewn into the rear nape pad of the helmet (Figure 7).

Table 2.
ZetaII fitting system lengths by HGU-56/P helmet size.

Helmet size	ZetaII length (in)
Small	16
Medium	16
Large	17
Extra-large	18

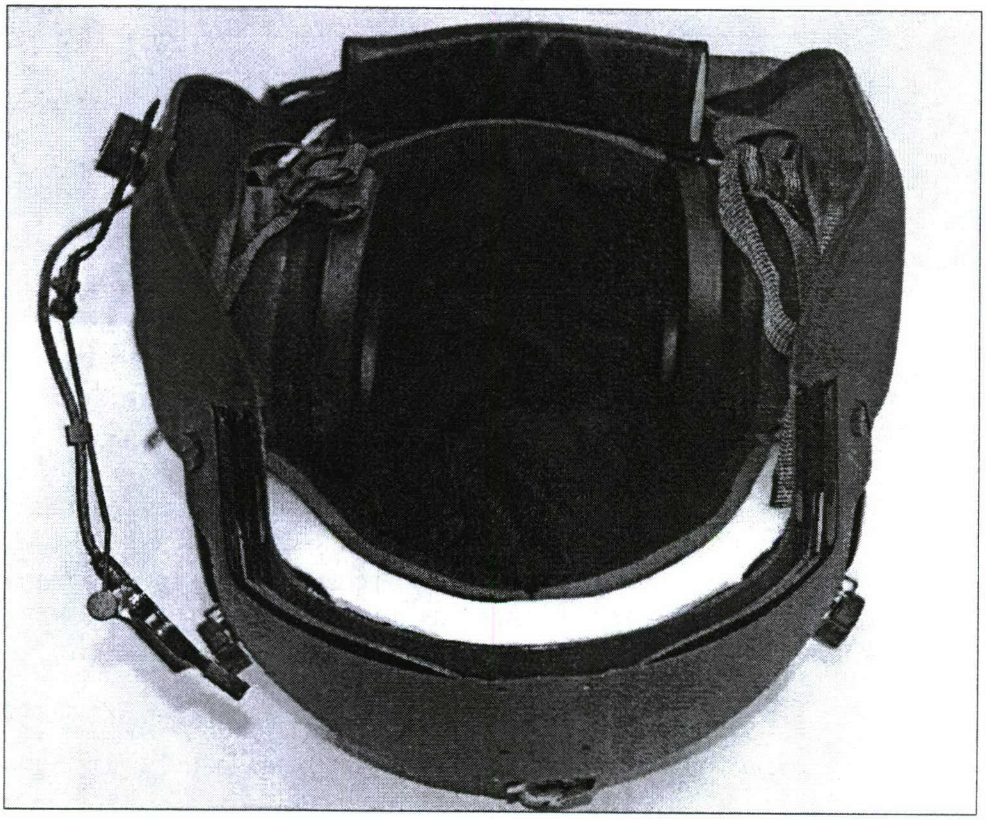

Figure 7. Extra-large HGU-56/P test helmet fitted with a ZetaII fitting system. The Zeta II installed in this helmet was 18 inches long and ¼-inch thick.

The ZetaII fitting system is manufactured in several thicknesses (also referred to as sizes), ranging from 1/4 (size 2) to 5/8 (size 5) inches thick, in one-eighth (1/8) inch increments (Table 3). All HGU-56/P helmets included in this evaluation were fitted with size 2 (1/4-inch thick) ZetaIIs. The size 2 ZetaII was chosen as the worst case condition, as it is the thinnest available ZetaII fitting system. If HGU-56/P helmets equipped with size 2 ZetaIIs were shown to provide the impact protection specified in FNS/PD 96-18 (Department of Defense [DOD], 1996), then HGU-56/P flight helmets equipped with thicker ZetaIIs should also provide at least the same level of blunt impact protection due to the added liner thickness.

Table 3.
ZetaII fitting system sizes and corresponding thicknesses (Erickson, 2008).

ZetaII size	ZetaII thickness (in)
2	0.250
3	0.375
4	0.500
5	0.625

Monorail drop tower

Blunt impact attenuation tests were performed on a guided, free fall drop tower (Figure 8) conforming to Federal Motor Vehicle Safety Standard number 218 (FMVSS 218) (Department of Transportation [DOT], 2006). Three magnesium headforms (Figure 9) were used for impacts to the front, rear, crown, left headband, and right headband impact sites. The test headform weights, as defined by the HGU-56/P purchase description (FNS/PD 96-18) (DOD, 1996), are provided in Table 4. The modified large headform had flanges along the left and right sides, allowing greater contact area between the helmet's earcup and headform.

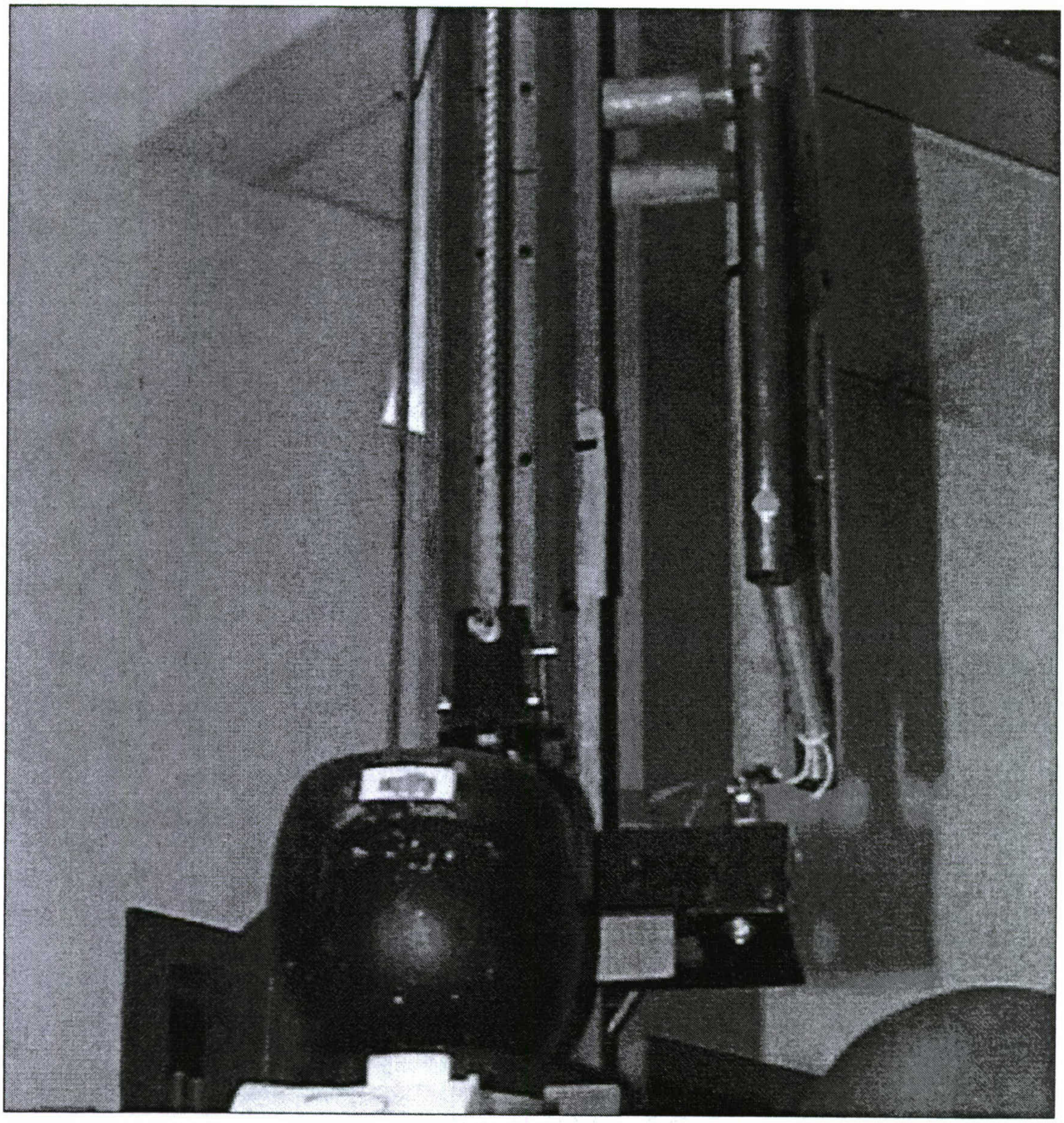

Figure 8. Guided, free fall drop tower (shown with the standard medium headform installed).

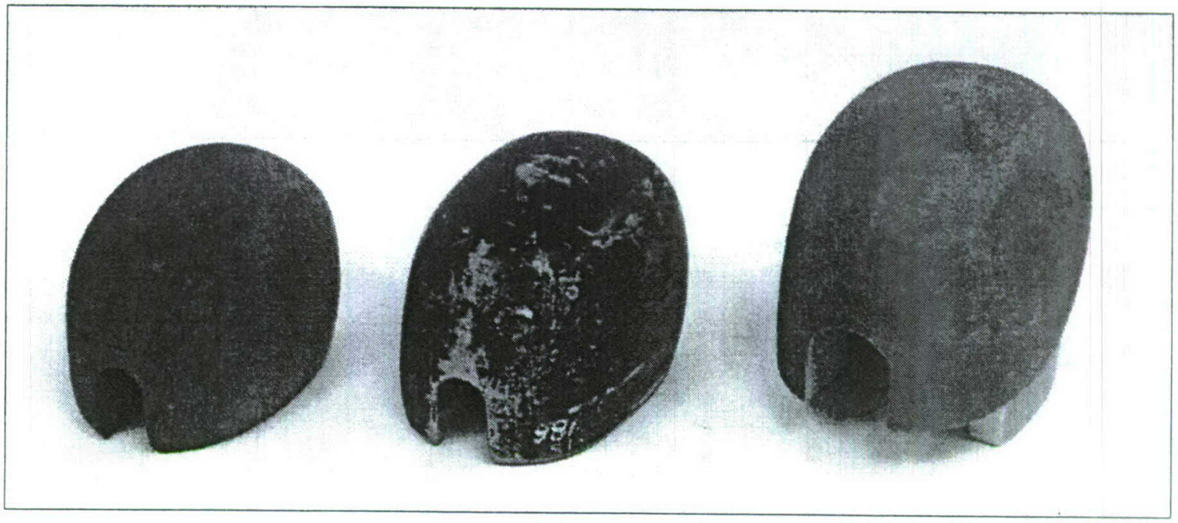

Figure 9. Drop tower headforms. Shown from left to right are the small (DOT size B), medium (DOT size C), and modified large (DOT size D) headforms. The modified large headform was configured with flanges along the left and right sides, allowing for more contact between the headform and the helmet earcups and making the headform useful for lateral earcup impact tests.

Table 4.
Test headform drop assembly weight.

Headform size	Required weight (lbs)	Weight tolerance (lbs)***	Actual weight (lbs)
Small (size B)	10.1*	+0.2, -0.0	9.9
Medium (size C)	11.0**		11.2
Large (size D) (modified)	13.4**		13.5

* Per FNS/PD 96-18 (DOD, 1996)
** FMVSS 218 (Department of Transportation, 2006)
*** Per American National Standards Institute (ANSI) Z90.1-1971 (ANSI, 1971)

Three channels of data were collected during blunt impact tests. A single-axis, linear accelerometer (Endevco model 2221D) installed in the center of mass of the headform measured vertical deceleration of the headform at impact. Impact force was measured using three load washers (Kiagg-Swiss model 902A) installed beneath the impact anvil. The velocity sensor (GHI Systems model VS300 Velocimeter) output voltage, which triggered the data acquisition system, was also recorded. Data were recorded at 10,000 samples per second per channel.

Experimental methods

The drop tower impact velocity was calibrated prior to testing to determine the drop heights needed to achieve the desired impact velocities. While the theoretical drop height can be calculated based on the necessary impact velocity, additional drop height is typically needed to overcome tower frictional drag. The standard medium headform was dropped from successively higher drop heights, starting at the theoretical drop height. Headform impact velocity was measured at each drop height. This process was repeated until the desired impact velocity was achieved.

Pre- and post-test system integrity checks were run before and after each test series. During these checks, the medium headform was raised to a drop height of 12 inches and impacted on a flat neoprene rubber anvil. Headform acceleration and impact velocity were recorded. This procedure was repeated three times both before and after each test series. The average peak headform acceleration recorded before the test series were compared the average peak headform accelerations measured post-test. A difference in the two averages of greater than 10 percent was indicative of possible damage to the test equipment during testing.

Blunt impact evaluations were conducted as specified in the HGU-56/P purchase description (DOD, 1996) with one exception. To assess the influence of cold temperatures on the performance of the HGU-56/P fitted with the ZetaII fitting system, two small and two medium HGU-56/P helmets fitted were subjected to impact tests after conditioning at 14 °F for a minimum of four hours (ANSI, 1971). Impact testing of HGU-56/P helmets conditioned at low temperatures is not specified in the HGU-56/P purchase description. However, knowing that the strength of the visco-elastic foam used in the ZetaII increases at low temperatures, the PM-AW was interested to know if the change in material properties would compromise the blunt impact characteristics of the HGU-56/P and requested that a small number of cold impacts be performed.

The 52 helmets were grouped by helmet size, environmental conditioning temperature, and impact sites. The distribution of the helmets among these groups is shown in Table 5. Table 6 specifies the target impact velocity ranges and pass/fail requirements for the different helmet impact sites as called out in the HGU-56/P purchase description (DOD, 1996). Helmets were subjected a single impact at each impact site (Figure 10) against a flat steel anvil.

Table 5.
HGU-56/P helmet test asset distribution by impact sequence and environmental condition.

Size		Number of helmets Ambient	Hot (122 °F)*	Cold (14 °F)*
Small	Impact sequence 1: Rear, front, crown	3	3	1
	Impact sequence 2: Left headband, right headband, crown	3	3	1
Medium	Impact sequence 1: Rear, front, crown	3	3	1
	Impact sequence 2: Left headband, right headband, crown	3	3	1
Large	Impact sequence 1: Rear, front, crown	3	3	0
	Impact sequence 2: Left headband, right headband, crown	3	3	0
Extra-large	Impact sequence 1: Rear, front, crown	3	3	0
	Impact sequence 2: Left headband, right headband, crown	3	3	0

* Environmentally conditioned helmets were soaked at the specified temperatures for a minimum of 4 hours but not greater 24 hours (ANSI, 1971).

Table 6.
Helmet impact velocity and headform peak acceleration requirements.

Impact site	Target impact velocity range (feet per second, fps)*	Maximum peak headform acceleration (G)
Crown	15.20 – 16.00	150
Front, rear, and left and right headband	18.70 – 19.68	175

* The impact velocity range is calculated based on the tolerance specified in ANSI Z90.1-1971 (1971), which is +0% to -5% of the target velocity

All tests of environmentally conditioned helmets were conducted within 5 minutes of removing the helmets from the environmental chambers. If testing could not be completed within this time, the helmets were returned for a minimum of 15 minutes before resuming testing (DOD, 1996).

For each impact test, the test helmet was mounted to the headform. The helmet chin and nape straps were adjusted to achieve a snug fit; helmets were not allowed to fit loosely or droop from the headform. The combined helmet/headform assembly was raised to the drop height necessary to achieve the desired impact velocity and released. The helmet/headform assembly impacted a flat steel anvil at the base of the drop tower.

Helmet impact velocity, headform impact acceleration, and impact force were recorded during each test. The impact force was recorded for informational purposes only. After each test, each helmet was thoroughly inspected for loose components and distorted hardware. Also, test headform orientation was checked and adjusted if necessary.

Data analysis

Headform acceleration signals were filtered at CFC1000 in accordance with Society of Automotive Engineers (SAE) Standard Practice J211-1 Part 1 (SAE J211-1) (1995). Peak headform accelerations were extracted from each filtered acceleration signal. Blunt impact protection was assessed by comparing the peak headform accelerations to the pass/fail criteria specified in FNS/PD 96-18 (DOD, 1996) and reproduced in Table 5. Peak headform accelerations exceeding the specified criteria would indicate that the HGU-56/P helmet configured with the ZetaII fitting system offers less blunt impact protection than the standard HGU-56/P equipped with the standard-issue four-layer TPL®.

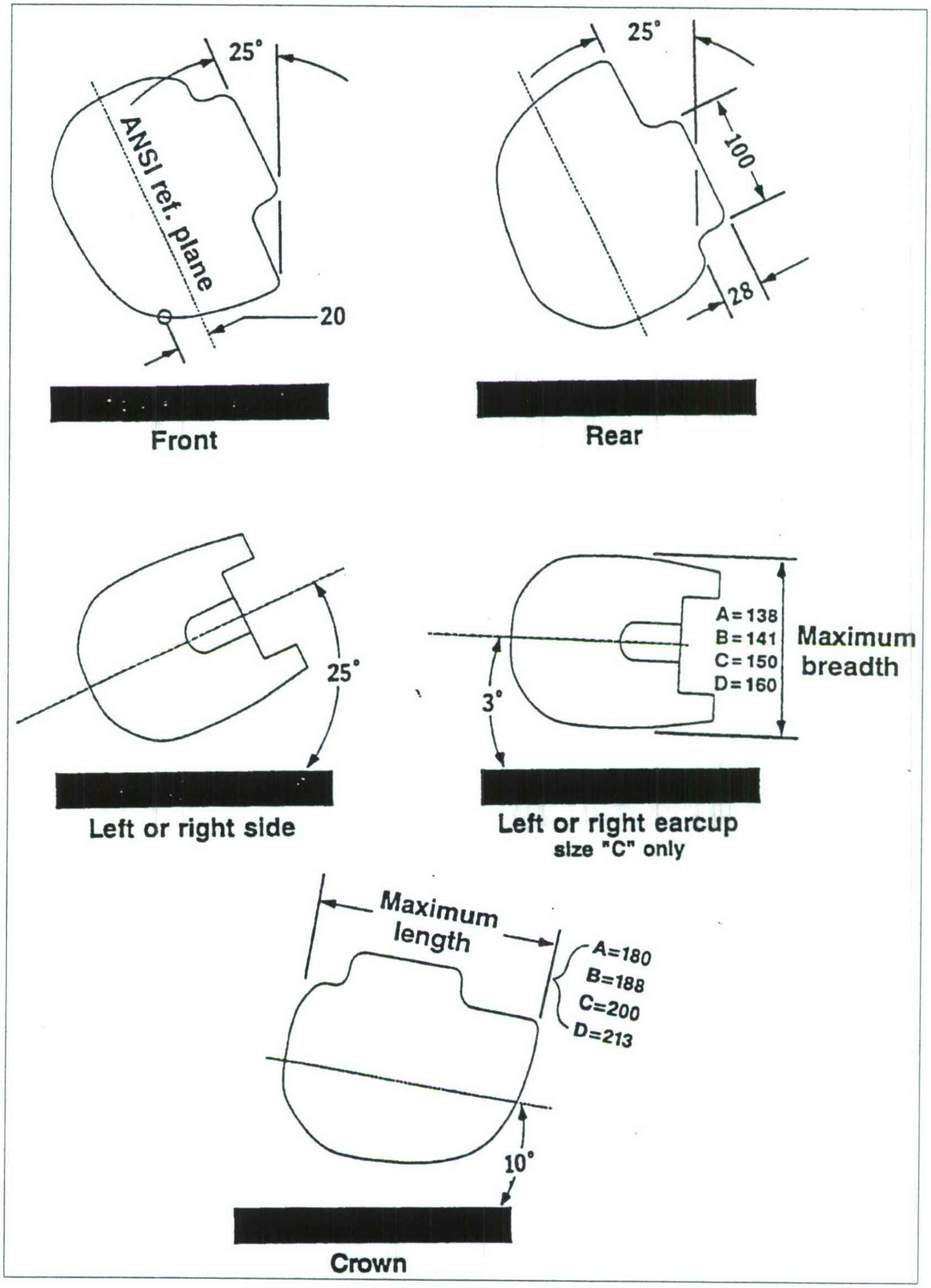

Figure 10. Droptower headform orientations corresponding helmet impact sites.

Results

Peak headform accelerations measured during each helmet impact test were grouped by impact site and environmental condition (Figures 11 through 13). In each figure, 150- and 175-G reference lines have been included to show the pass/fail criterion for each impact site.

Inspection of Figures 12 and 13 show no rear impacts to medium helmets conditioned at 14 °F and only two rear impacts to the large helmets conditioned at 122 °F, respectively. Results from two rear impact tests were excluded from the analysis due to instrumentation problems. Figures 14 and 15 show acceleration and transmitted force profiles from the two excluded rear impact tests. Both figures show a sudden increase in acceleration around 80 msec with no corresponding rise in transmitted force. For this reason, the acceleration spikes may be attributed to an intermittent problem in the accelerometer instrumentation. As a result, peak accelerations from these two tests were excluded from the consideration.

In general, installation of the size 2 ZetaII fitting system in place of the four-layer TPL does not appear to degrade the impact protection of the helmet. For all impacts except one, HGU-56/P helmets equipped with the size 2 ZetaII fitting system limited peak headform accelerations to the pass/fail thresholds specified in FNS/PD 96-18 (DOD, 1996). This finding is independent of helmet size, impact site, or helmet temperature.

In the one exception, a peak headform acceleration of 185 Gs resulted from an impact to the rear of an XL HGU-56/P conditioned at ambient laboratory temperature (Figure 11). Three additional XL HGU-56/P helmets were subjected to rear impacts. The additional helmets had been subjected previously to left headband, right headband, and crown impacts. Even so, rear impacts to these helmets resulted in peak headform accelerations below the pass/fail criterion of 175 Gs (DOD, 1996). The three additional rear impact data points are plotted in Figure 11.

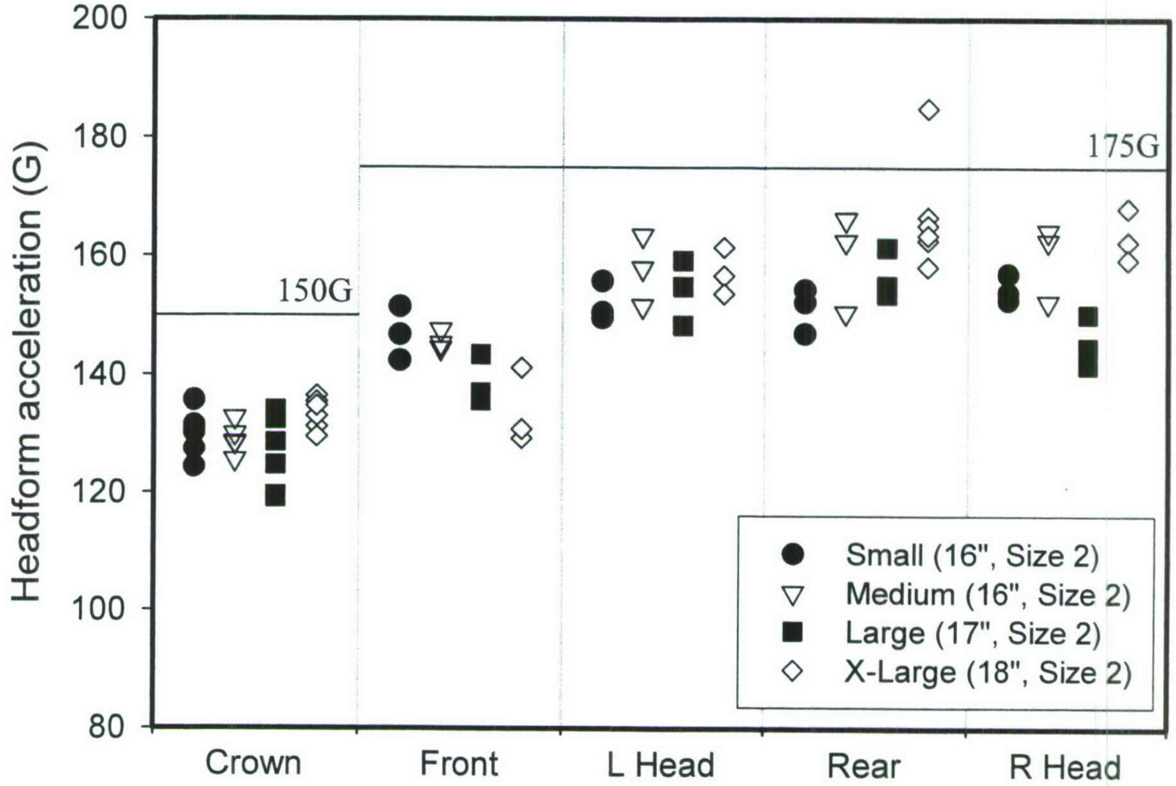

Figure 11. Peak headform accelerations for HGU-56/P helmets configured with size 2 ZetaII fitting systems and conditioned at ambient laboratory temperature (75 °F). The 150 G and 175 G reference lines represent the pass/fail criterion for the respective impact site.

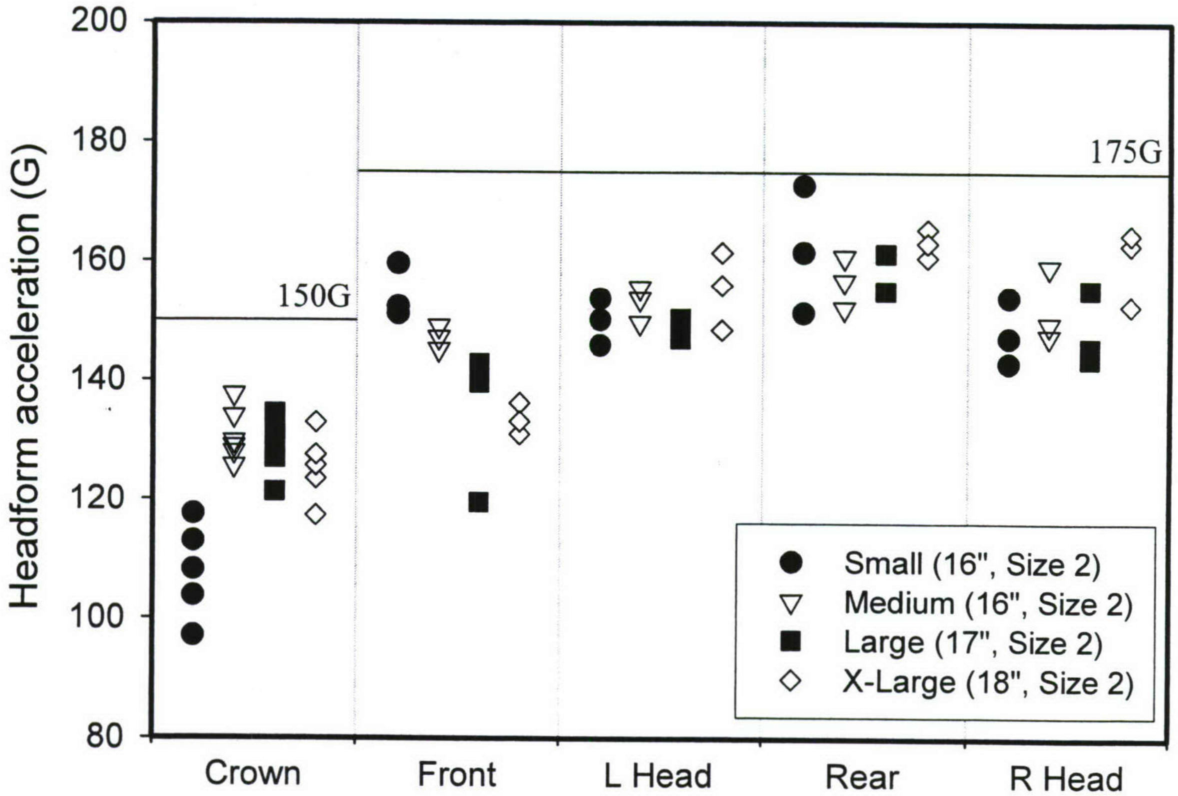

Figure 12. Peak headform accelerations for HGU-56/P helmets configured with size 2 ZetaII fitting systems and conditioned at 122 °F. The 150 G and 175 G reference lines represent the pass/fail criterion for the respective impact site.

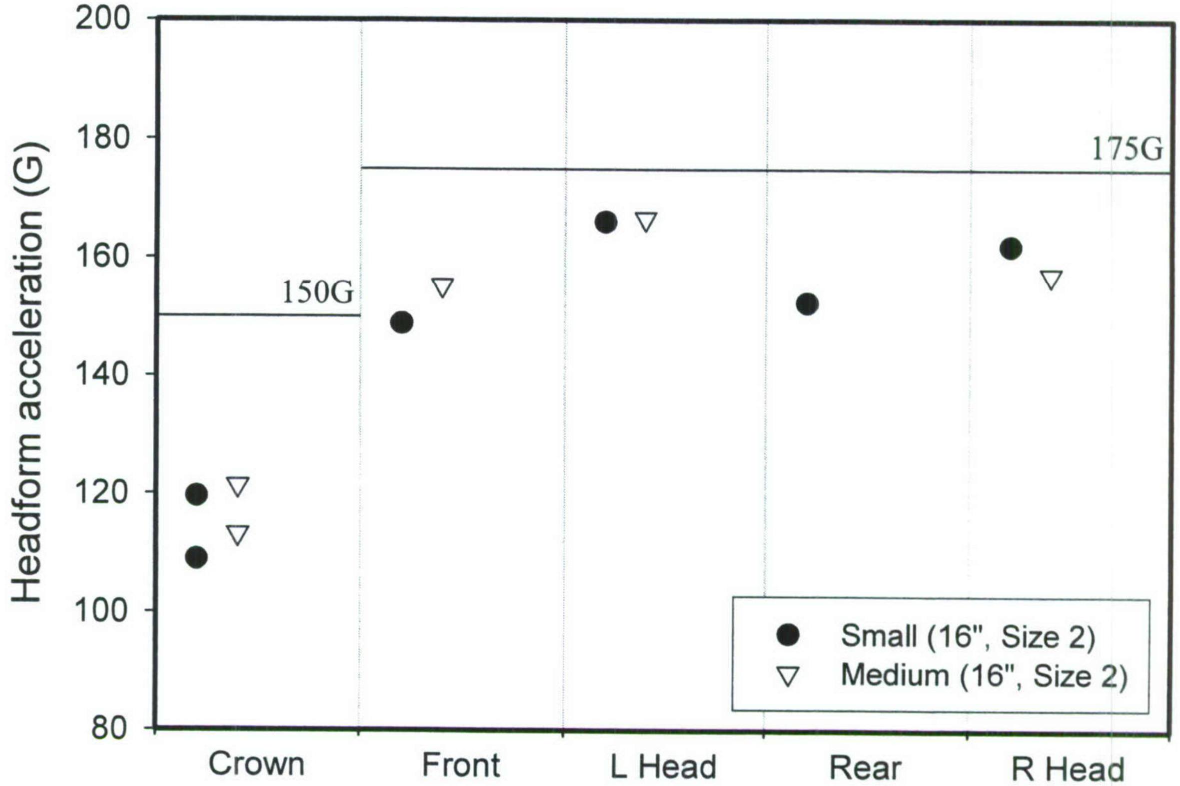

Figure 13. Peak headform accelerations for HGU-56/P helmets configured with size 2 ZetaII fitting systems and conditioned at 14 °F. The 150 G and 175 G reference lines represent the pass/fail criterion for the respective impact site.

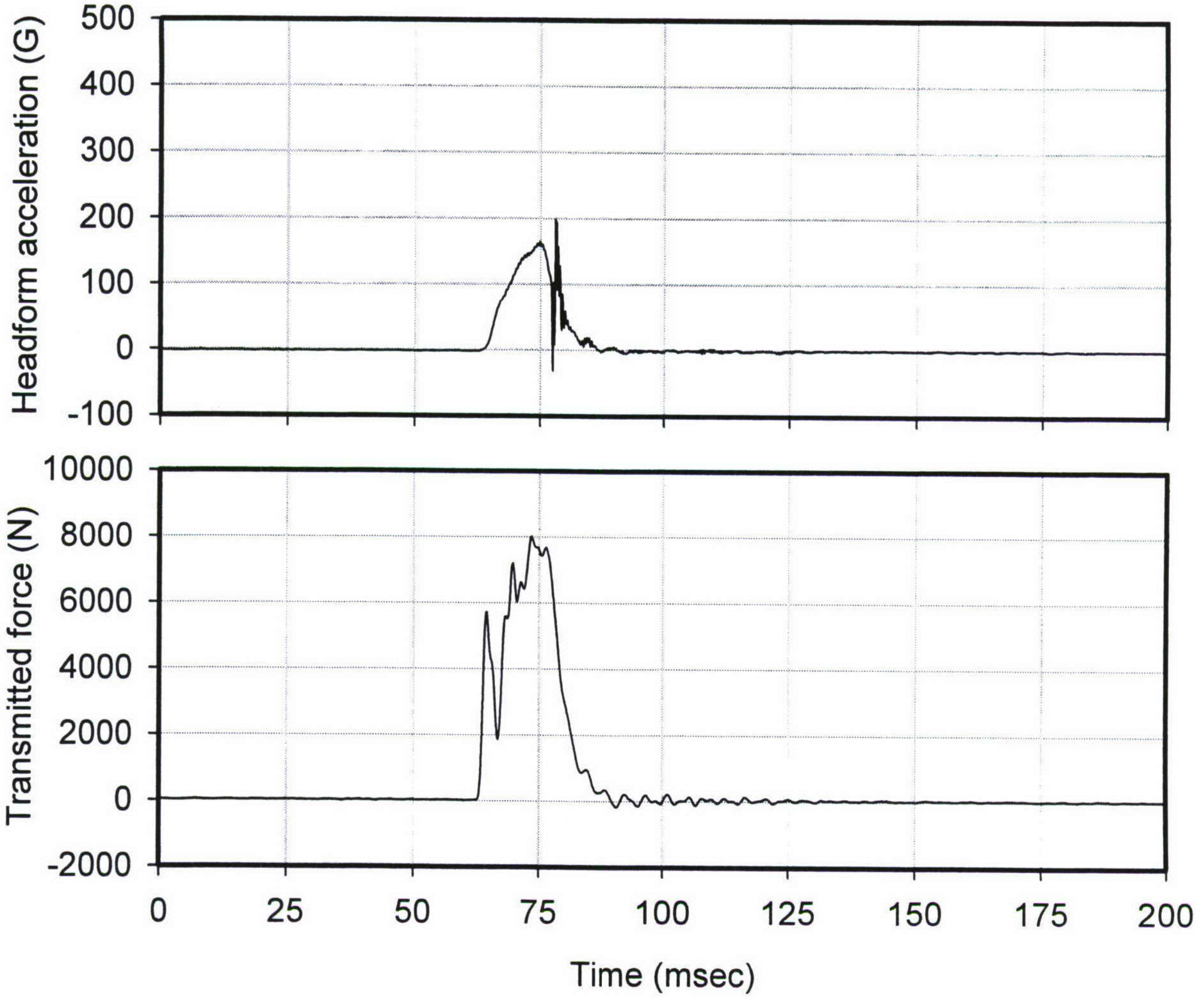

Figure 14. Acceleration and transmitted force profiles for one rear impact to a medium helmet conditioned at 14 °F. The instrumentation spike occurs in the acceleration profile at approximately 80 msec. No corresponding spike occurs in the transmitted force. The peak headform acceleration measured within the first 80 msec of the acceleration signal filtered at 1650 Hertz was 164.5 Gs, which is below the 175 G pass/fail criterion for the rear impact site.

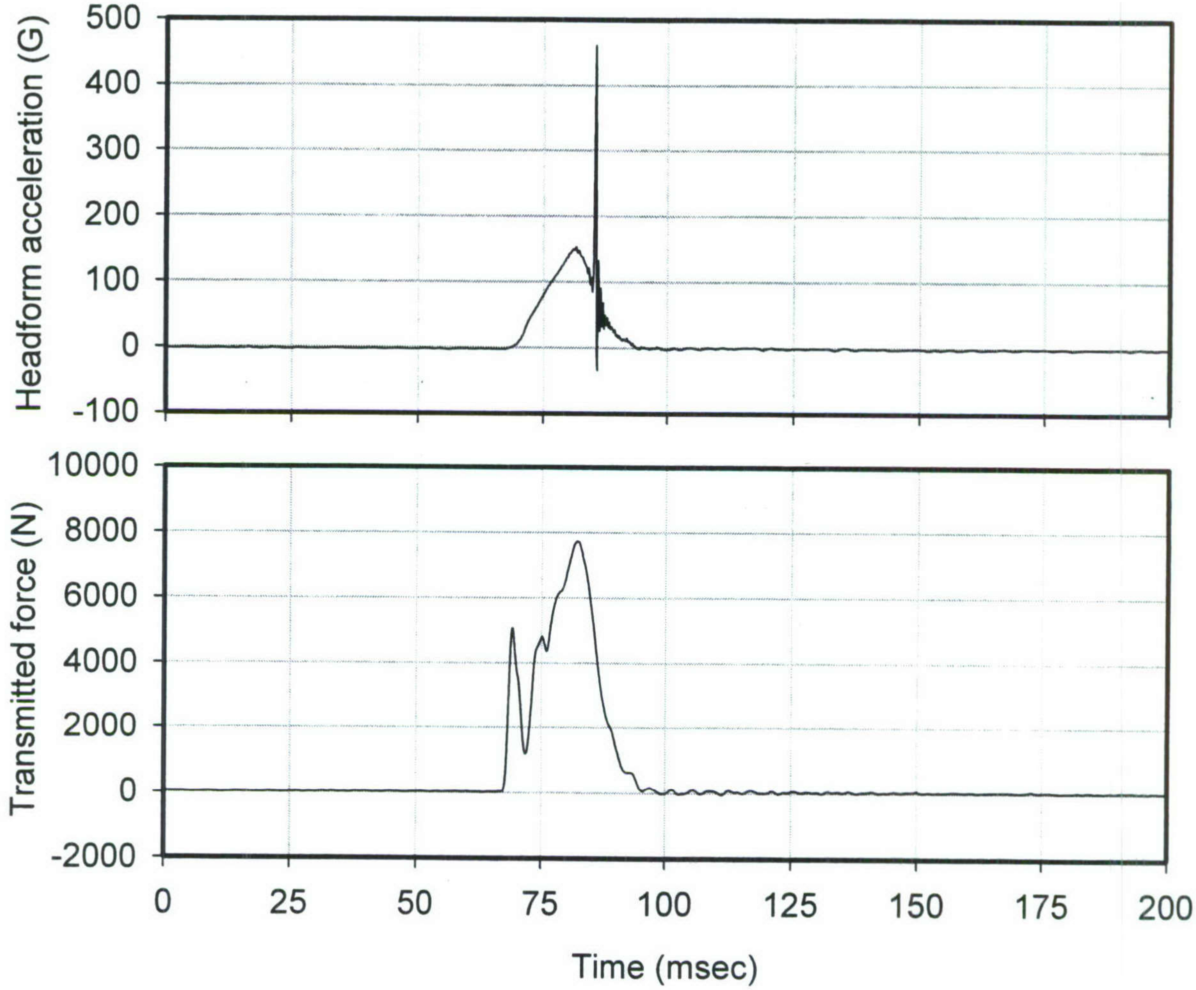

Figure 15. Acceleration and transmitted force profiles for one rear impact to a large helmet conditioned at 122 °F. The instrumentation spike occurs in the acceleration profile at approximately 85 msec. No corresponding spike occurs in the transmitted force. The peak headform acceleration measured within the first 85 msec of the acceleration signal filtered at 1650 Hertz was 153.4 Gs, which is below the 175 G pass/fail criterion for the rear impact site.

Discussion

The ZetaII fitting system appears to mitigate the blunt impact performance degradation noted in previous tests of the HGU-56/P AIHS equipped with the original ZetaLiner™ fitting system. In those tests, blunt impact protection of the HGU-56/P AIHS was reduced, particularly during impacts to the rear of helmets conditioned at 122 °F. In comparison, impacts to HGU-56/P helmets fitted with the ZetaII fitting system and conditioned 122 °F (Figure 12) resulted in no peak headform accelerations above the pass/fail criterion specified in FNS/PD 96-18 (DOD, 1996).

Additionally, Figures 11 through 13 show that 1 of 156 impact tests resulted in a peak headform acceleration above the specified pass/fail criterion (DOD, 1996). Additional impacts under the same test conditions (rear impact to an XL helmet conditioned at ambient laboratory conditions) resulted in peak accelerations below the 175 G pass/fail criterion (DOD, 1996). This would indicate that the one peak head acceleration in excess of 175 Gs may be a outlier and not indicative of a systemic problem like that seen in the earlier evaluation of the original ZetaLiner™.

The improved performance of the ZetaII fitting system may be due to its less complex design. The original ZetaLiner™ (Figure 4) was comprised of several small triangular sections of visco-elastic foam sewn together in a cloth cover. Having several smaller foam pieces allowed the original ZetaLiner™ to conform to the interior contour of different helmet shells, but also resulted in the fitting system having several exposed seams. If impacted directly above an exposed seam, particularly the seam running along the centerline of the ZetaLiner™, the seam could concentrate the impact loads and result in high peak headform accelerations. The ZetaII fitting system is comprised of fewer foam pieces and has fewer exposed seams (Figure 5). The centerline seam has been removed, eliminating the possibility of concentrating the impact loads during rear impacts.

Another potential reason for the improved performance of the ZetaII fitting system is that care was taken to choose ZetaII fitting systems of appropriate lengths for each helmet size tested (Table 2). ZetaII fitting systems should fully engage the hook and pile tape located on the interior front of the EAL, as well as the hook and pile tape sewn into the nape strap, while sitting flush against the contour of the EAL (Figure 7). If a fitting system of insufficient length is installed such that it fully engages the hook and pile tape in the front and rear of the helmet, the fitting system may not fit flush against the interior contour of the EAL. This may result in a void between the fitting system and the EAL. As a result, the helmet would not be optimally coupled to the wearer's head, and during a rear impact, the added space between the fitting system and EAL may result in dynamic overshoot. Given the potential influence of ZetaII helmet liner length on blunt impact protection, detailed fitting procedures will be needed to ensure that aviation warfighters choose the proper ZetaII fitting system for their particular size HGU-56/P AIHS.

An exact explanation for the instrumentation faults is not readily available at this time. System integrity checks conducted at the beginning and end of each day's testing were normal and did not indicate any damage to the accelerometer. All test instrumentation was within calibration and had not exhibited any need for repair prior to this evaluation.

The 1/4-inch thick (size 2) ZetaII fitting system was used during this evaluation because it represented a worst case condition, i.e., the thinnest ZetaII available. The assumption was made that thicker ZetaII fitting systems would provide at least the same amount of blunt impact protection as the size 2. Unpublished data from a previous, limited assessment of large HGU-56/P flight helmets equipped with the 1/2-inch-thick (size 4) ZetaII fitting system showed that this assumption is valid; peak headform accelerations resulting from impacts to these HGU-56/P AIHSs equipped with ZetaII fitting systems remained below the pass/fail thresholds prescribed in the HGU-56/P AIHS purchase specification (DOD, 1996).

Conclusions

The results of this evaluation indicate that the impact protection of the HGU-56/P AIHS is not degraded with the use of the ZetaII fitting system. When modified with size 2 ZetaII fitting systems, small, medium, large, and extra-large HGU-56/P AIHSs meet the blunt head impact requirements prescribed in the HGU-56/P AIHS purchase specification (DOD, 1996).

ZetaII fitting system length may influence the blunt impact protection provided by the HGU-56/P AIHS. As such, scrupulous fitting procedures will be needed.

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McEntire, B.J. 1998. U.S. Army aircrew helmets: Head injury mitigation technology (reprint). Fort Rucker, AL: U.S. Army Aeromedical Research Laboratory. USAARL Report No. 98-12.

Society of Automotive Engineers. 1995. Recommended Practice J211-1. Instrumentation for impact test – Part 1 – Electronic instrumentation. Warrendale, PA. SAE J211-1. Revised March 1995.

Appendix A.

List of manufacturers.

Gentex Corporation
P.O. Box 315
Carbondale, PA 18407

Oregon Aero, Inc.
34020 Skyway Drive
Scappoose, OR 97056

Appendix B.

ZetaII fitting system part numbers assigned by Oregon Aero, Inc.

ZetaII size/thickness (in)	ZetaII length (in)			
	15	16	17	18
2 / 0.250	9A-0015-101	9A-0016-101	9A-0017-101	9A-0018-101
3 / 0.375	9A-0015-102	9A-0016-102	9A-0017-102	9A-0018-102
4 / 0.500	9A-0015-103	9A-0016-103	9A-0017-103	9A-0018-103
5 / 0.625	9A-0015-104	9A-0016-104	9A-0017-104	9A-0018-104

Source: Erickson (2008)

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